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Enhancing and Evaluating the Impact of MATTERS

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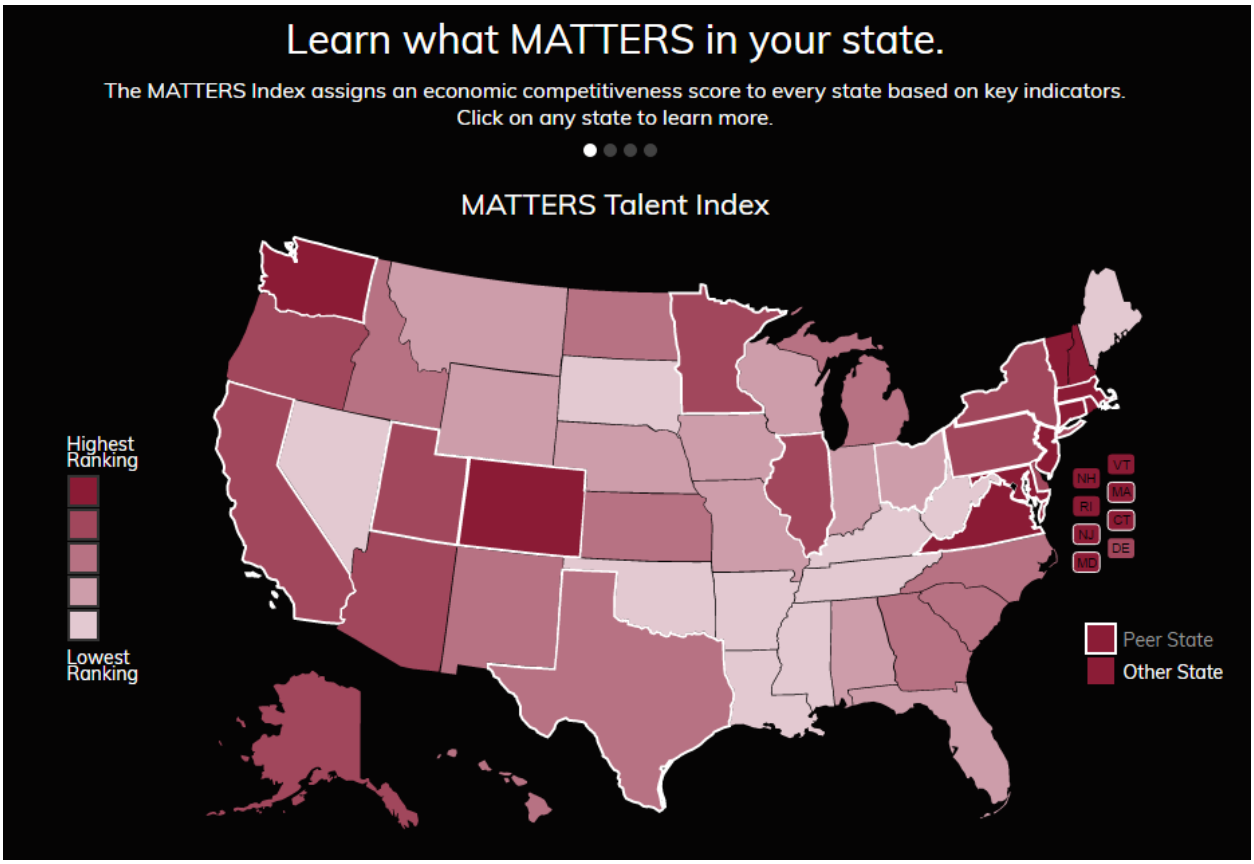

by Justin Charron

WPI

MATTERS
MASSACHUSETTS TECHNOLOGY, TALENT, AND ECONOMIC REPORTING SYSTEM

MASSACHUSETTS HIGHTECHNOLOGYCOUNCIL

Enhancing and Evaluating the Impact of MATTERS

An Interactive Qualifying Project
Submitted to the Faculty of
WORCESTER POLYTECHNIC INSTITUTE
in partial fulfilment of the requirements for the
Degree of Bachelor of Science

by
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Report Submitted to:

Professor Elke Rundensteiner
Worcester Polytechnic Institute

EXECUTIVE SUMMARY

MATTERS and MHTC

The Massachusetts Technology, Talent, and Economic Reporting System (MATTERS) was developed for the Massachusetts High Technology Council (MHTC) by students and faculty at Worcester Polytechnic Institute (WPI) over a series of three consecutive projects in 2014, 2015, and 2016.[1] With the help of supporting outside companies such as the MITRE Corporation and Boston-based digital content agency MESH as well as the guidance of Professor Elke Rundensteiner and PhD student Caitlin Kuhlman, these teams of students built and expanded upon a web site to help MHTC in furthering their goal of making Massachusetts the most attractive place to grow a technological business by advocating and lobbying pro-technology to government entities and business owners.

MATTERS combines US states by comparing different metrics from many different data sources into one site where the user is free to explore and visualize the data. Following previous user studies conducted in the 2016 MQP project (Bogatov, 2016) and a user study by the Bentley University User Experience Center, the goal of this IQP project was to address the results of these studies by adding new features to the site and modifying existing features in order to make the site more user friendly and intuitive to use.[2] By improving the user experience of MATTERS, MHTC is increasing its social impact on the public. This should also boost its lobbying power in pro-technology advocacy. This new version of the site with added and improved features is now dubbed "MATTERS 2.0" and the development portion of this project in part supported the preparation and release of MATTERS 2.0.

[1] Please see Chapter 2 to read more on the 2014, 2015, and 2016 projects.
[2] More information about the 2016 project and Bentley User Study can be found in Chapter 2.

Site Updates and Added Features

In addition to improving existing features and addressing a list of bugs identified in the prior release of the site, this project expanded upon the responsive design of the site and integrated the handling of categorical data into the Data Explorer page. These elements were key in that they expand the range of users that can use MATTERS by supporting mobile devices as well as existing users with PC desktop machines. The site was tested using a variety of screen sizes to ensure that the responsive design continued to be uniform even after the features added by this IQP project.

User Study and Results

After the site updates and enhancements, another user study was conducted as part of this IQP project to evaluate the usability of the upgraded site features. The study asked users to browse to the MATTERS site and perform a number of tasks, after which questions were asked on how easy the features were to use and how well they presented the data to the user. To develop the user study, a first phase consisting of a set of face-to-face interviews was conducted with volunteers from WPI's Database Systems Research Group as a testing phase of the study. This phase verified that the study was sufficiently succinct and free of ambiguities. After improvements based on this experience, the study was made available using Qualtrics software through WPI. (Qualtrics, 2017) In addition, the user study was posted as two separate jobs, one for the Data Explorer page and one for the State Profile page, using Amazon Turk to get anonymous survey participants, called "workers", to use the site and provide their feedback. (Amazon, 2017) Using the research and analytic tools provided in the Qualtrics software suite, the results of the survey were evaluated. A list of updates that may further increase the MATTERS user experience was derived based on the feedback provided in the survey results.

Overall, most survey participants were satisfied with how the site looked and felt visually and how it presented the data it had to offer to the user. The study itself can be seen in Appendices A through C of this paper, and the data collected from the surveys can be seen in Appendix D.[1]

Future Work

Following the evaluation of the user study, a list of suggestions was compiled from the survey results as well as information obtained from the face-to-face interviews and through additional testing of the site. This list was presented to my advisors and, following the conclusion of this project, I will continue to work with Professor Rundensteiner and Caitlin Kuhlman on addressing the items of this list in order to get MATTERS 2.0 prepared for release on MHTC's servers. The list of suggestions on improvement can be found at the end of the Survey Results section of Chapter 4 and in Chapter 5 of this paper.

[1] More about how the survey was created and an evaluation of the results can be found in Chapter 4.

ABSTRACT

The MATTERS website was developed by students and faculty at Worcester Polytechnic Institute sponsored by the Massachusetts High Technology Council. It provides a single web resource where various key cost, economic, and talent metrics are collected and then utilized to form national rankings for each state in the United States. Following an independent user study done by the Bentley University User Experience Center, the goal of this project was to address key points made in the study and further improve the MATTERS website. In addition, a new user study was conducted to analyze how well the new features performed. A list of suggestions for possible future enhancements to the site was generated using two assessment instruments, namely, a user study and an interview feedback mechanism.

ACKNOWLEDGEMENTS

I would like to thank the following individuals and organizations for their support and assistance throughout my project:

- **Professor Elke Rundensteiner,** my advisor from WPI for giving me the opportunity to complete this project and for her guidance throughout its course.
- **Caitlin Kuhlman, WPI,** for her guidance and support in familiarizing me with the website and assistance in its development.
- **Members of WPI's Database Systems Research Group (DSRG),** for giving me useful feedback on the site and volunteering to conduct face-to-face interviews for the user study.
- **Worcester Polytechnic Institute**, for providing me the education and opportunities needed for me to complete this project.

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CHAPTER 1: INTRODUCTION

The goal of this project was to expand on the Massachusetts Technology, Talent, and Economic Reporting System (MATTERS) website by addressing a report from a user study done by Bentley University, and adding new key features to the site.[1] The MATTERS site provides a single web resource where various key cost, economic, and talent metrics are collected and then used to form national rankings for each state in the United States. (MHTC, 2017a) In conjunction with MHTC, the MATTERS website was developed by students and faculty at WPI through a series of project starting in 2014.[2] It was also worked on by software architects from the MITRE corporation and web designers from MESH.[3] The initial Interactive Qualifying Project (IQP), done in 2014, created the initial prototype of the MATTERS website as well as its backend. (Gvozdneovic, 2014) It introduced the concept of using many datasets, called metrics, to compare the economic and social aspects that affect the technological climate of each state in the United States. This project was followed up by a Major Qualifying Project (MQP) in 2015 that integrated new data sources to the dashboard and improved the way data importing and administration worked. (Fortier, 2015)

While both these projects worked on the front-end interface of the website (the "dashboard"), their main goals were to evaluate the social impact of MATTERS and to make it work more efficiently. In 2016 a second MQP was done at WPI, this time focused instead on improving the backend system that existed to manage the data on the site. (Bogatov, 2016) In addition, this project introduced new features for custom metrics and different roles for end users of the site. For administrators, this made it easier to add new metrics to the site. It also added

[1] See Appendix D for the full Bentley University study reports.
[2] See (Gvozdneovic, 2014), (Fortier, 2015), (Bogatov, 2016)
[3] See (MITRE, 2017), (MESH, 2017)

the capability to compute “indexes”, which are collections of different metrics in a certain category where each state is provided a rank in that index based on a custom formula combining the metrics. These indexes can be seen on the dashboard of MATTERS 2.0 as the MATTERS Talent, Tax, Business Cost, and Quality of Life indexes. It also refactored the backend of the client and server side code to improve functionality, and streamline future development by students. A documentation wiki was created in the 2015 MQP (Fortier, 2015) to help new developers who are not familiar with the site to learn how it works and get started developing in it. This wiki was expanded upon and developed further by both Caitlin Kuhlman and the 2016 MQP project (Bogatov, 2016) as new features were added to the site.

To study how user-friendly the site was and find areas that could be addressed in order to improve it, MHTC contracted the Bentley University User Experience Center to perform a user study. The study was beneficial to MHTC and the WPI developers working on the site in identifying key areas of improvement that could be made and places and terminology that could be clearer.

This study and its findings, along with a small list of site features that were proposed and never fully implemented, was the motivation for this project. The main goal of this IQP project was to address key feedback provided in the Bentley University study and incorporate new and previously started features to the site. The site was also tested heavily to find bugs that existed in the site and to fix them. A new user study was then performed at WPI to learn the impact these features had on the user experience. By improving the user experience of the site, the social impact of the site was increased. This in turn helps MHTC further its goals of increasing its impact on policy holders and bringing business to the state of Massachusetts.

CHAPTER 2: BACKGROUND

MATTERS and MHTC

The Massachusetts High Technology Council, also known as MHTC (MHTC, 2017a), is an organization that advocates and lobbies pro-technology to the government on behalf of high technology organizations in Massachusetts. They do this with the goal of making more job opportunities in Massachusetts and increasing the productivity of its businesses and citizens. They also emphasize the leadership role of businesses to drive competiveness in the quality and cost of education. MHTC believes that by working together and with the state government, leaders of high-tech companies can drive social and economic growth in Massachusetts. (MHTC, 2017c)

The Massachusetts Technology, Talent, and Economic Reporting System (MATTERS) was originally prototyped by a group of students at WPI as an Interactive Qualifying Project (IQP) sponsored by the MHTC. (Gvozdenovic, 2014) The MHTC sponsored the project in order to develop a tool which would provide quick access to "high fidelity cost and talent competitiveness metrics" (Neamtu, R. et al., 2017) related to the economic competitiveness of Massachusetts. This online data analysis dashboard would facilitate data-driven decision making by both the council and the public, providing a comparison of metrics over time and across US states. The original dashboard prototype contained several metrics under four main categories that the user could view: Talent, National, Cost, and Economy. You could compare data across states, and for each metric a raw data value and a national ranking were provided. The data could also be viewed across several years. Sample images of the dashboard created by the 2014

project can be seen in Figure 2.1. MATTERS was also later supported by collaboration with partners of MHTC including the MITRE Corporation and MESH design agency.[1]

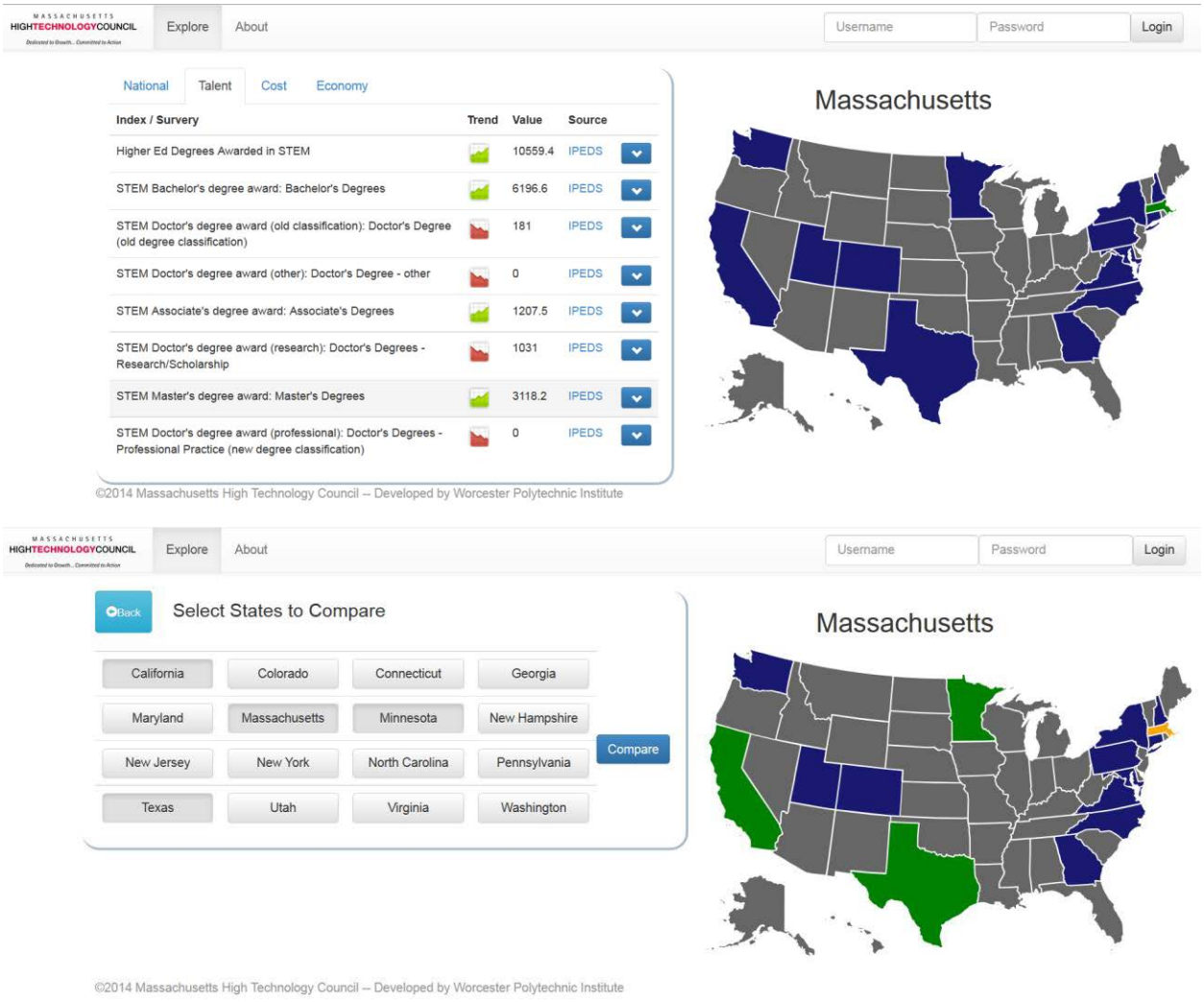

Figure 2.1. Initial MATTERS homepage mockups.

The objective of MATTERS was to provide an easily accessible way to measure and evaluate Massachusetts' competitive position in relation to the rest of the country. This falls in line with MHTC's goal of making Massachusetts the "world's most attractive place in which to

[1] For more information on MITRE and MESH's role, see the "Other Work and Outside Companies" section of this chapter.

create and grow a high technology business." (MHTC, 2017c) MATTERS also lists a set of 15 "peer states" that MHTC has identified as similar to Massachusetts. These "peer states" are made up of the 10 leading technology states as well as the top 5 states in Milken Institute's "State Tech and Science Index", excluding any duplicate states. (MHTC, 2016a)

After the initial prototype was well received by the council, MHTC partnered to develop MATTERS into a public online tool. Development at WPI was led by Caitlin Kuhlman, working with council members MITRE and MESH who joined to advise and evaluate the development project. A number of graduate and undergraduate students were also involved in development of the site, and the initial dashboard was completely redesigned with input from design experts at MITRE and MESH. MATTERS was publicly released at the 2014 annual MHTC meeting, and this initial public release is dubbed "MATTERS 1.0" and a sample image of the new Data Explorer page can be seen in Figure 2.2. From the MATTERS site: "MATTERS consolidates a set of key cost, economic, and talent metrics along with independent national rankings into a single source for use by all parties." (MHTC, 2017a)

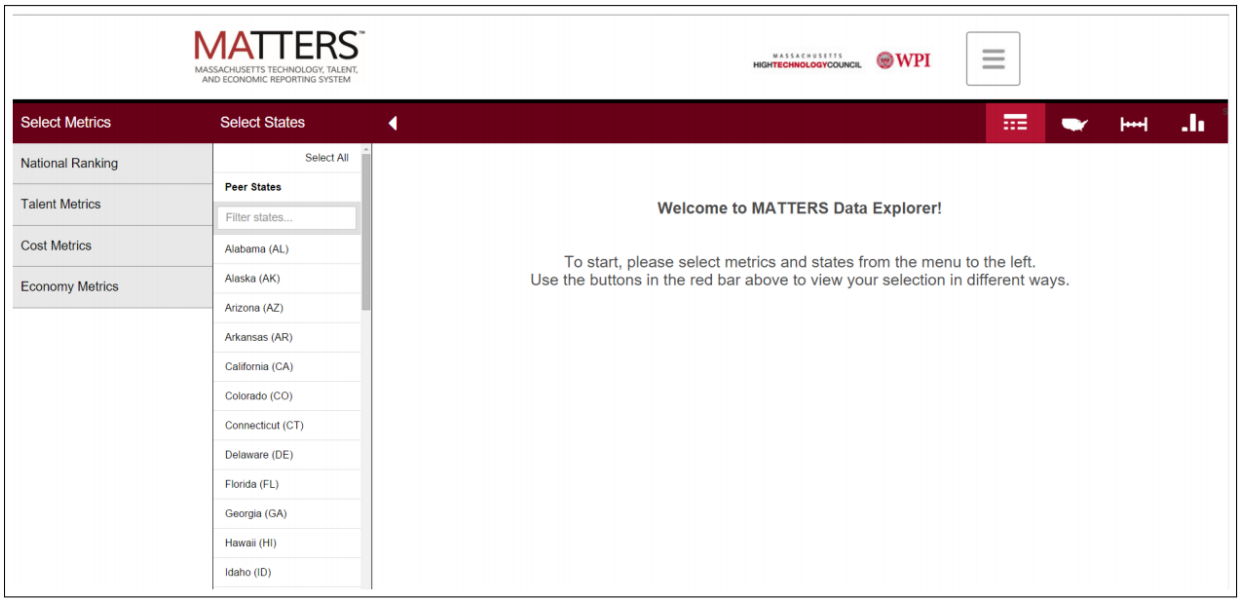

Figure 2.2. MATTERS 1.0 Data Explorer.

The initial 2014 IQP and subsequent release of MATTERS 1.0 was followed in 2015 with another project at WPI, this time a Major Qualifying Project (MQP). The goal of the 2015 project was to "improve the data integration and administration center for the MATTERS dashboard". (Fortier, 2015) It sought to integrate a number of new metrics into MATTERS from different data sources and improve the way data is added and maintained through a newly revamped administration center, which can be seen in Figure 2.3. The team made the administration center easy to use for non-technical users and automated the process of adding new sources as much as possible. The project did update the front-end of the site, but most of the work was in the back-end database system and the data management through the administration center.

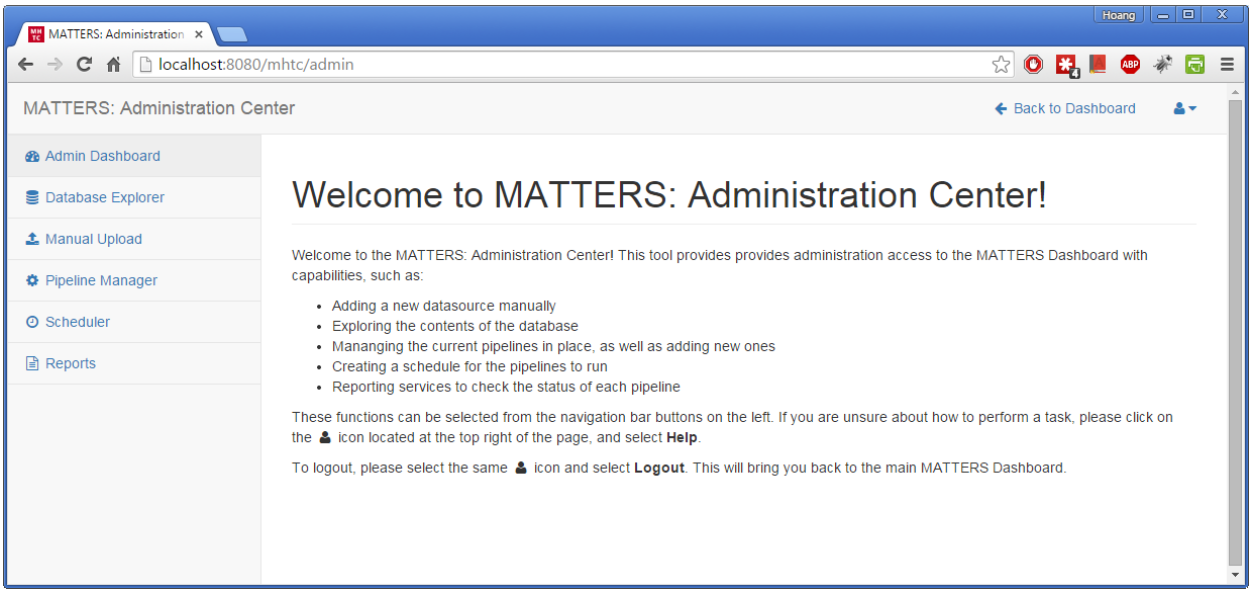

Figure 2.3. Administration Center from 2015 project. (Fortier, 2015)

In 2016, a second MQP project at WPI was sponsored by MHTC to improve the database and server backend of MATTERS and expand upon the Administration Center's capabilities. This project introduced the concept of custom metrics in the site. Users within MHTC could

now login to the site and define custom metrics that were either from data sources that they uploaded to the site or calculated metrics similar to the MATTERS indexes that exist on the site's home page. The project also introduced the API of retrieving metrics from within MATTERS. Lastly, they wrote documentation to introduce new developers to the site who are not previously familiar with it. The backend of the server side code was also cleaned up from the previous two projects.

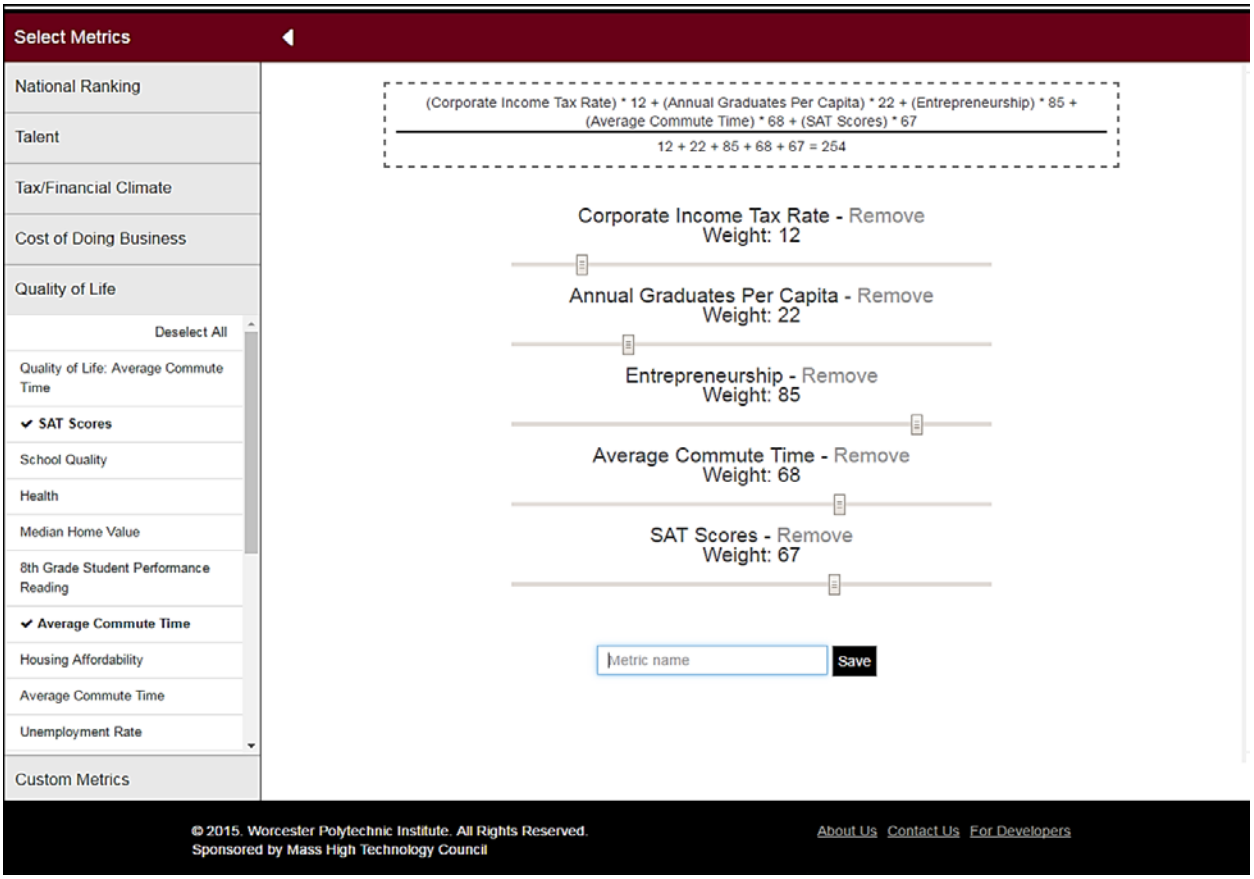

Figure 2.4. Metric Builder from the 2016 MQP project. (Bogatov, 2016)

The 2016 MQP conducted a user study at the end of their project to get feedback on how well the metric builder worked on how easy it was to use by users who were not familiar with the system. This study and its results can be found in Appendix D of this project.

Other Work and Outside Companies

Since its conception, the site has been overseen by Professor Elke Rundensteiner at WPI and she has been the main driving force, working with MHTC in its continued evolution. Working along with Professor Rundensteiner has been Caitlin Kuhlman, a PhD student in the Computer Science department at WPI. Both are members of the Database Systems Research Group. Caitlin has been the lead researcher and developer of MATTERS since she came to WPI in 2014 and has served as a mentor for all of the WPI projects done for the site after the initial 2014 IQP. Besides the initial major projects, the site has been worked on by several undergraduate and graduate students at WPI, both formally in projects and informally as side development work.

The main styling and layout of the landing page of the site was provided to WPI by MESH for the release of MATTERS 1.0. MESH is a content and digital marketing agency out of Boston that was also the developer of MHTC's main website. (MESH, 2017, MHTC, 2017b) They styled the landing page to look and feel similar to MHTC's own website, and have advised on design for the site ever since.

The MITRE Corporation played a large role in the 2015 project as technical consultants. They provided feedback on the system architecture of the MATTERS backend, making recommendations on software development best practices and tools. They also performed an in-depth report on the performance and benchmarking of the site, which can be seen in the 2015 report. (Fortier, 2015)

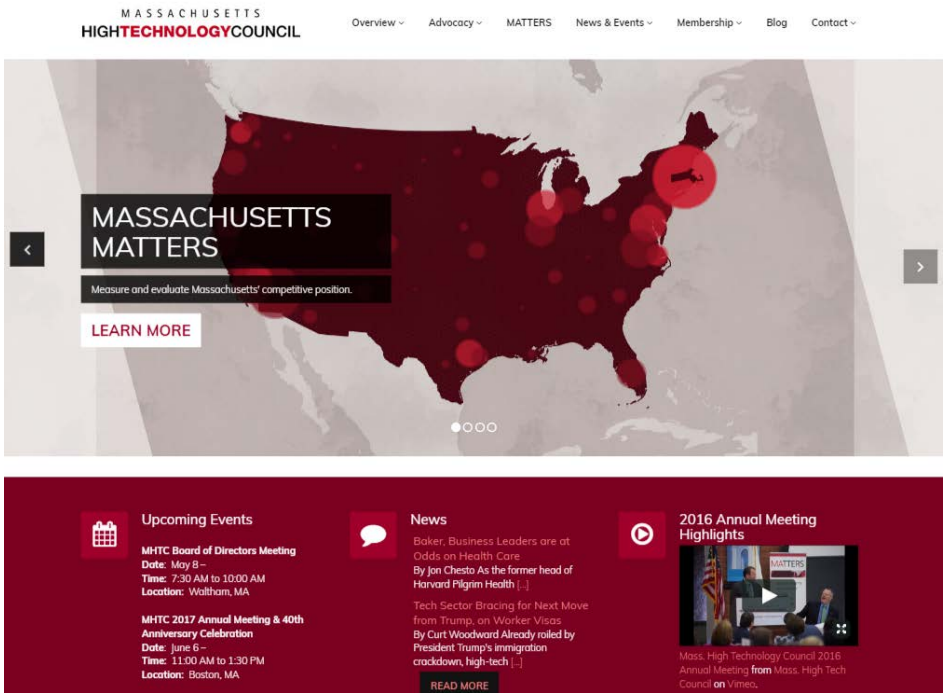

Figure 2.5. MHTC's main website. (MHTC, 2017b)

Bentley User Study

Following up from the user study done in the 2016 MQP, WPI and MHTC wanted to do a user study to find out how user friendly and interactive the website was, particularly the data explorer. For this, WPI contracted Bentley University's User Experience Center (UXC) to perform a detailed user study and collect as much feedback as they could for the site. Bentley's UXC are experts with many years of experience and research in UX design and study. They have many well-known and global clients that contract them to help create, test, and optimize websites and applications including Philips, Geico, and many more. (Bentley University, 2017)

The study had participants take part in a 60-minute in-person interview where they were asked to perform multiple tasks on the site and the interviewer took note of their behavior while performing these tasks. MHTC provided a list of research questions they were hoping to answer and the tasks were formed with these goals in mind. The results were compiled into a 4-page

report, which can be viewed in Appendix D of this paper, and then presented to WPI and MHTC. The report listed key areas of the site that users seemed to have the most trouble on and made recommendations on how to solve issues that users were having. It also pointed out areas of the site that worked well and were friendly and intuitive to use. The results of this study led to a hefty list of future additions and revisions to the MATTERS site, which is what sparked the start of this IQP project.

Following the success of previous student projects and the public release of MATTERS, WPI and MHTC began working on a number of improvements for a 2.0 version of the site. The rich collection of data in MATTERS provided MHTC with the means to begin developing a number of indices to measure the performance of the high tech economies in different US states. To incorporate and highlight this important new development the site was redesigned. A new State Profile page was added to view in-depth data for each index ranking each state, multiple maps were added to the landing page of the site to view each state's ranking in all four indices, and a large amount of data was added to support each of the four indices. All these new features, and the outstanding usability issues revealed by the user study, necessitated the work done in this IQP.

CHAPTER 3: METHODOLOGY

Site Updates

The results of the Bentley University UXC study and previous evaluation revealed a number of possible improvements that could be made to the usability of MATTERS. There also existed a backlog of previous unfinished development features that had not made it in to the released version of the site due to pushes to meet time requirements of releases of the site. This led to the start of development on a new major release of MATTERS, dubbed MATTERS 2.0, and this IQP was proposed to advance the development of the 2.0 release. When this project started MATTERS 2.0 was in its early stages of development and many things such as bug fixes and fine-tuning of the layout of the site had not yet been dealt with. The first portion of this IQP was heavily geared towards implementing these new features into the current development site and getting MATTERS 2.0 ready for launch. Several of these features are described in detail below, and the complete list of features in MATTERS 2.0 can be found in the appendices section of this paper.

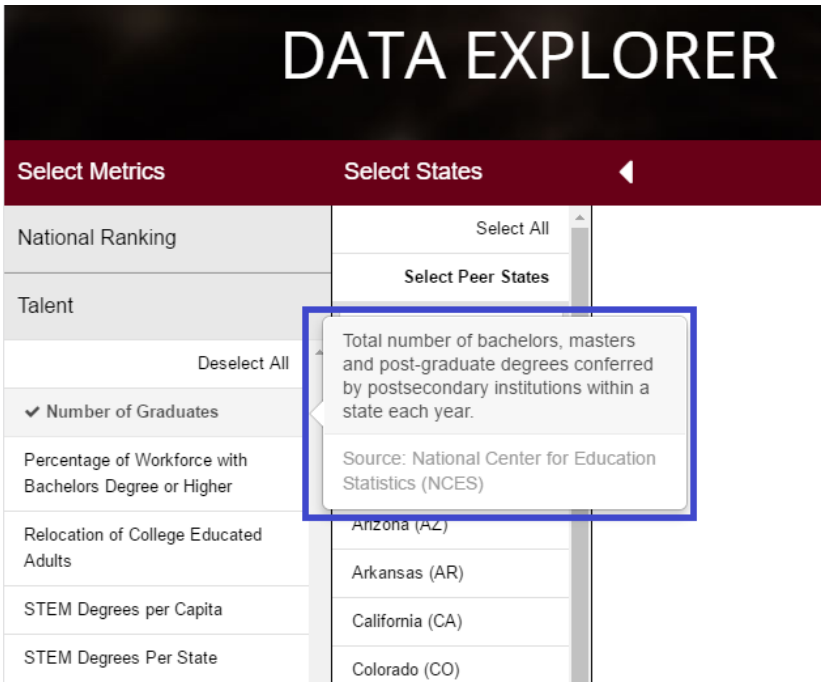

Figure 3.1. Metric description popup.

In the Data Explorer page, each metric has a popup that displays when the user hovers over its entry in the menu. Many of these old descriptions were either blank or needed updating and so new descriptions were provided to us by MHTC and the database was updated accordingly. These descriptions were also added to the sections in the State Profile page.

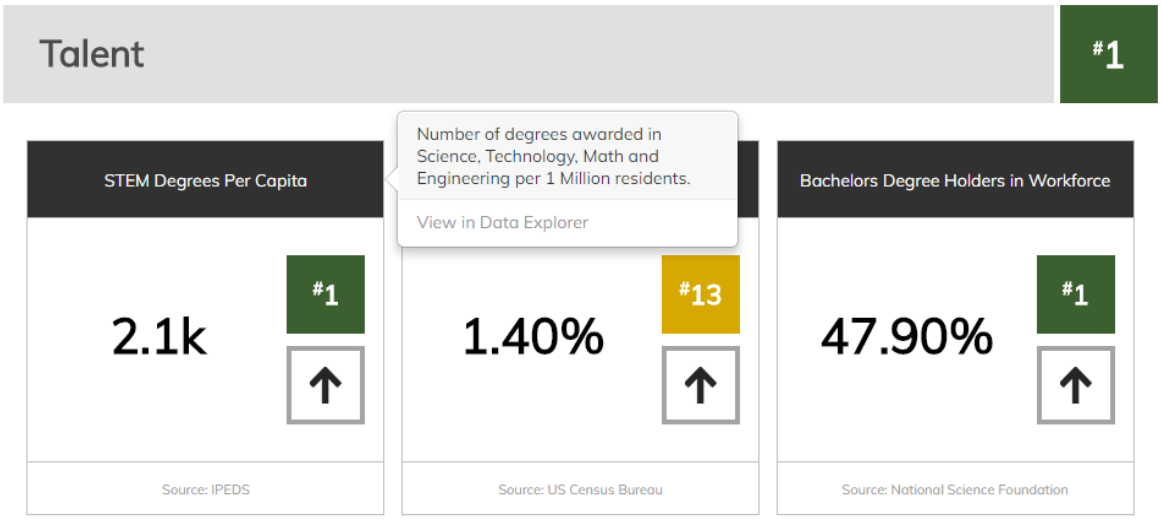

Figure 3.2. Metric description tooltips in State Profile page.

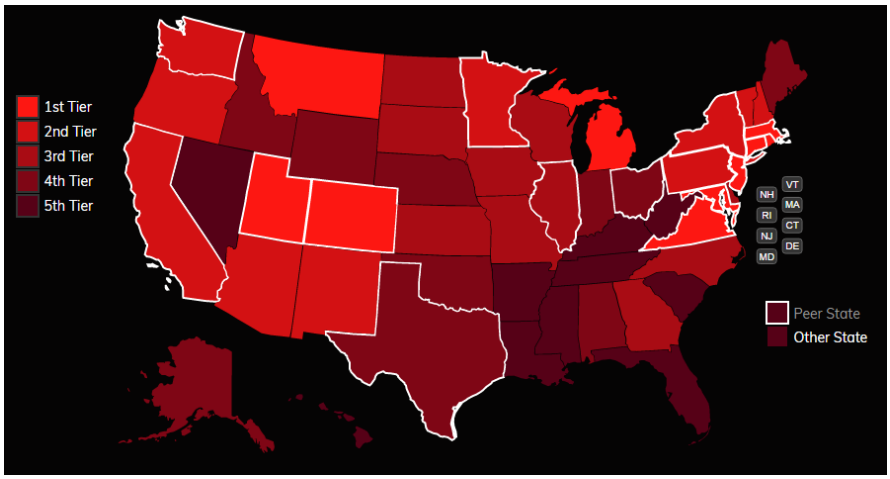

Figure 3.3. Old landing page heatmap.

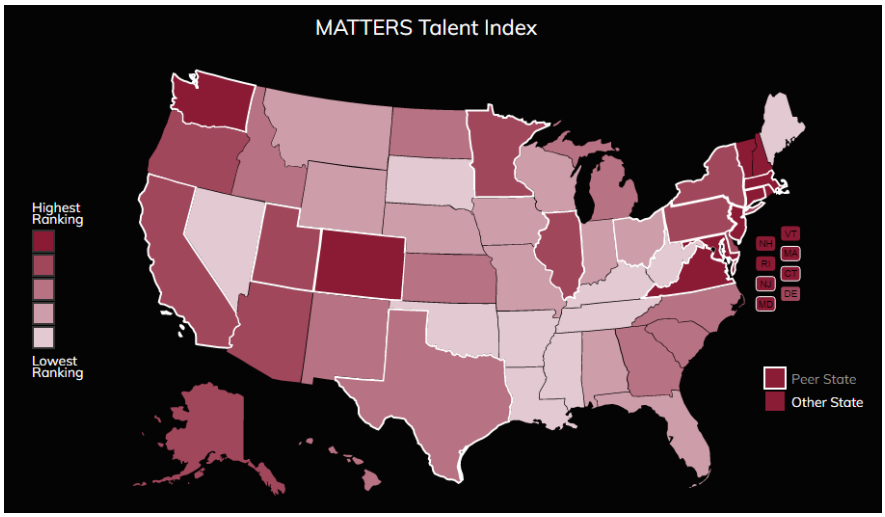

Figure 3.4. MATTERS 2.0 landing page heatmap.

Previously, the maps on the home page of MATTERS had each state put into one of 5 "tiers" for each index, and they were labeled "Tier 1", "Tier 2", etc. in the map key. One of the points noted in the Bentley Study was that users were not able to figure out what the "tiers" meant or which tier was ranked highest and lowest. To clear the confusion, the highest and lowest ranking tiers were marked accordingly in the key and the labels in between were removed. The color schemes for all 4 maps were also updated for improved readability.

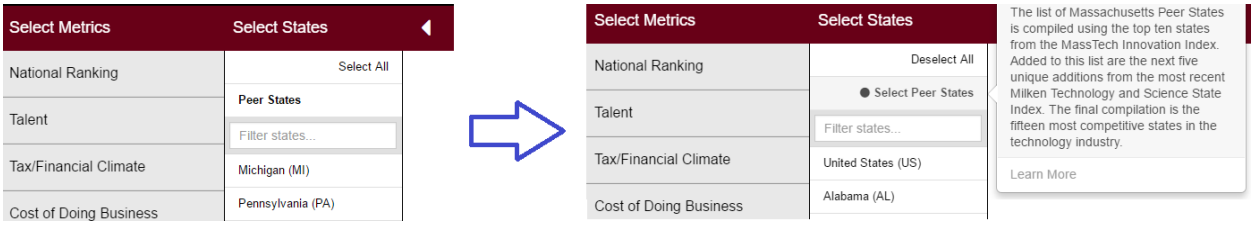

Figure 3.5. Peer States selection button update.

The Bentley study showed that many of the users were not aware of the "Peer States" button being selectable, and that even fewer understood what a peer state really was. This was fixed by making the button appear visually similar to the "Select All" button above it and adding the word "Select". Also, the popup was updated to have a more fitting description of what a peer state is.

Also seen in Figure 3.5 is the alphabetical sorting of the states in the menu, with United States moved to the top of the list.

Categorical Data

As previously mentioned, there were a number of features for the MATTERS site that development was started on but either were not completed or did not make it into the release of MATTERS 1.0. One such feature was the handling of "categorical" data. Categorical data is data that is not represented by a decimal or integer number, but rather the data falls into a number of categories. Previously, this information was presented to the front-end using a number representing each category, and the only way to find what each number represented was to read the tooltip for that metric. For example – in the "Corporate Income Tax-Sourcing Rules" metric, a value of 1 indicates Market Based, 2 indicates Cost of Performance, and so on.

This information as shown to the front-end user does not work well and it is difficult to visualize what the data represents. To address this issue, a feature was developed to show the

data as the categories themselves instead of the numbers representing them. Implementing this feature was somewhat cumbersome, however, because to do this every part of the server and front-end that read metric data in from the database had to be reformatted as well as the structure of the database. Because of this, the feature was never fully developed and therefore not implemented in the site's release.

To implement the handling of categorical data, I first had to start with the old Git branch that the categorical data feature was developed in. This branch was many revisions out of date from the most recent dev branch at the time. In order to incorporate the changes into the most recent site, I had to create my own branch and manually merge the changes in each area from the old branch into the new one. I then expanded upon this merged product to get the end result in Figure 3.7. You can see how the new data handling works for both numerical data in Figure 3.6 as well as categorical data.

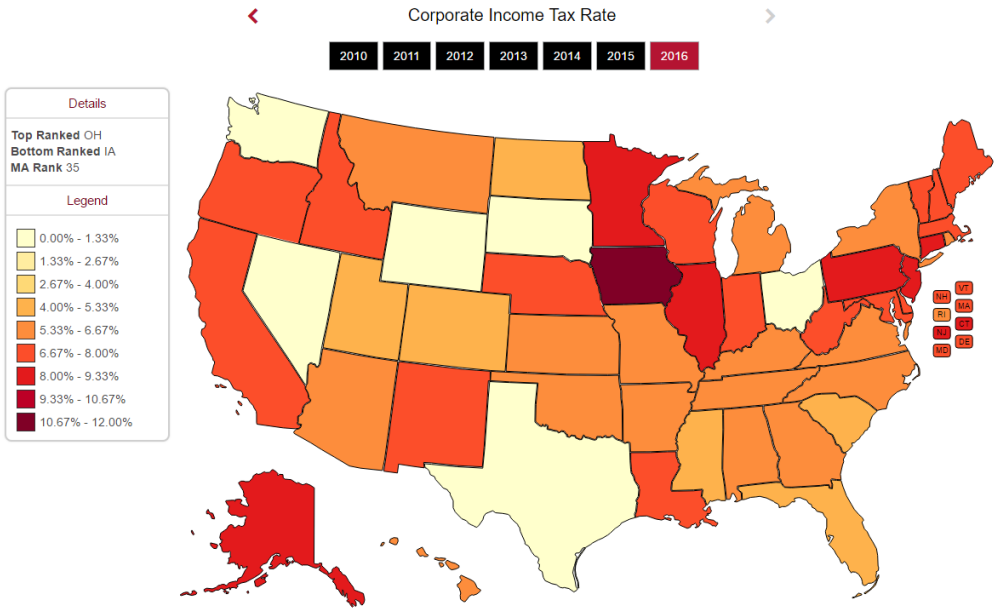

Figure 3.6. Numerical data in Explorer page heatmap.

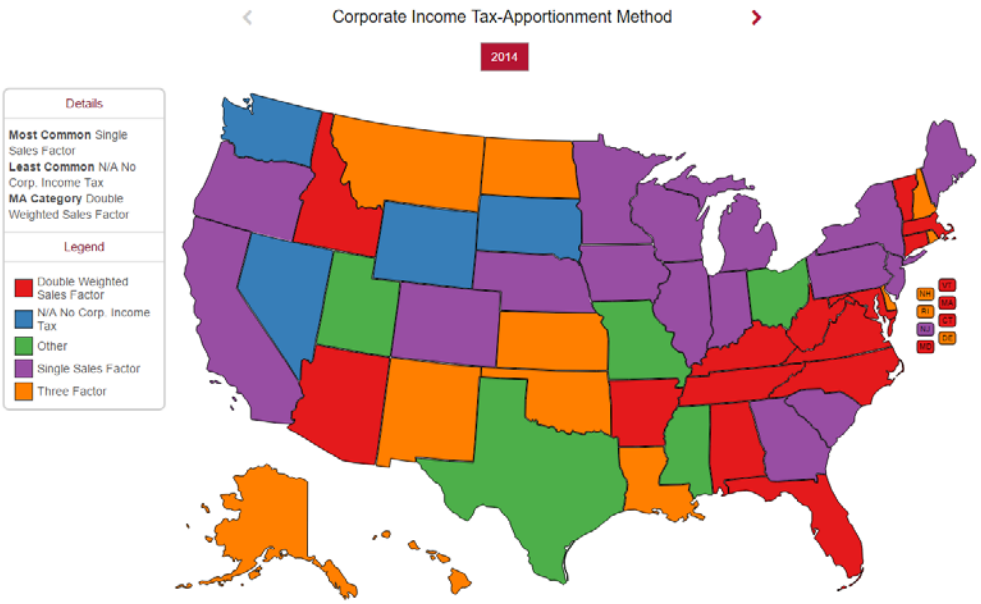

Figure 3.7. Categorical data in Explorer page heatmap.

Social Media Sharing

Figure 3.8. Custom URL implementation.

A new aspect to the site was the ability to share the site to social media. Previously, in order to share the MATTERS site to another person you would have to send them the URL to the page and also tell them what metrics and states you had selected as well as the visualization and year you were looking at. Also, printing the page did not work well so that was not an acceptable method of sharing the page. To address this, a feature was added to save the current selections a user had and to make those selections when the page is loaded from a custom URL.

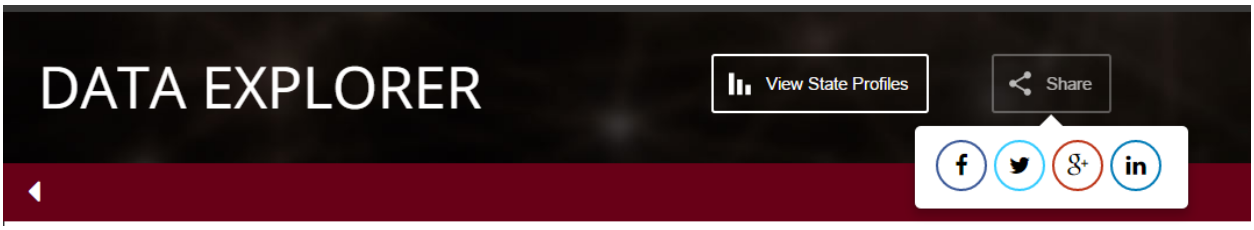

Figure 3.9. Social media share button on Explore page.

With this custom URL, all the selections you make on the site are saved and you can send this link to a colleague and when they open the link they will see exactly what you saw when you sent it to them. Also, a sharing button was added to the Explore and State Profile pages to allow users to share the page to social media with the click of a button.

Responsive Design

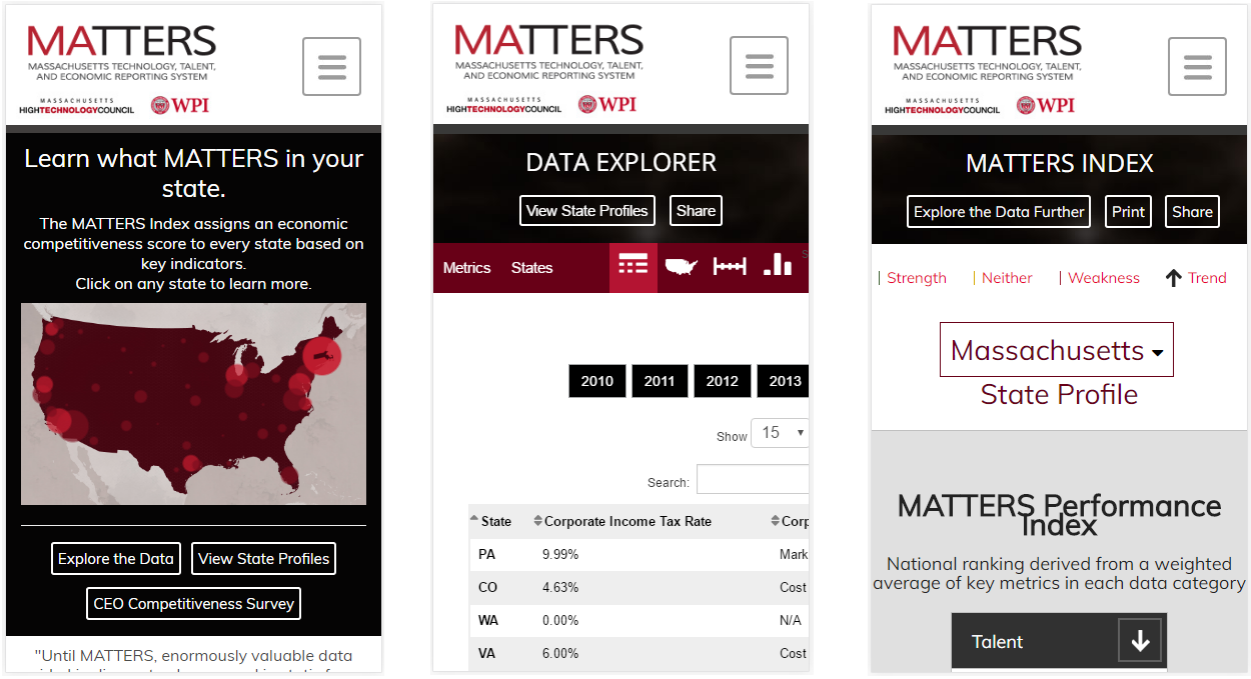

Figure 3.10. Landing, Explore, and State Profile mobile pages.

One of the major features wanted in the release of MATTERS 2.0 was the optimization of the site for users on mobile devices. On mobile devices, namely smartphones but also some

smaller tablets, text from desktop pages can be small and hard to read. There are many such ways of doing this, including using different CSS stylesheets based on the size of the screen (Coyier, 2010), using libraries such as Bootstrap that have built-in responsive designs (Bootstrap, 2017), or using javascript responsive methods to make your web pages adaptive as the page is resized (Google Developers, 2017). When considering the design of the MATTERS 2.0 site, a combination of all three of these methods were used. The site was already built using the bootstrap framework, so including Bootstrap classes in page elements such as containers allows us to use Bootstrap's responsive design. For more custom elements in the site, a combination of hard-coded CSS designs for certain page widths and responsive widths of containers using javascript adaptive methods are used.

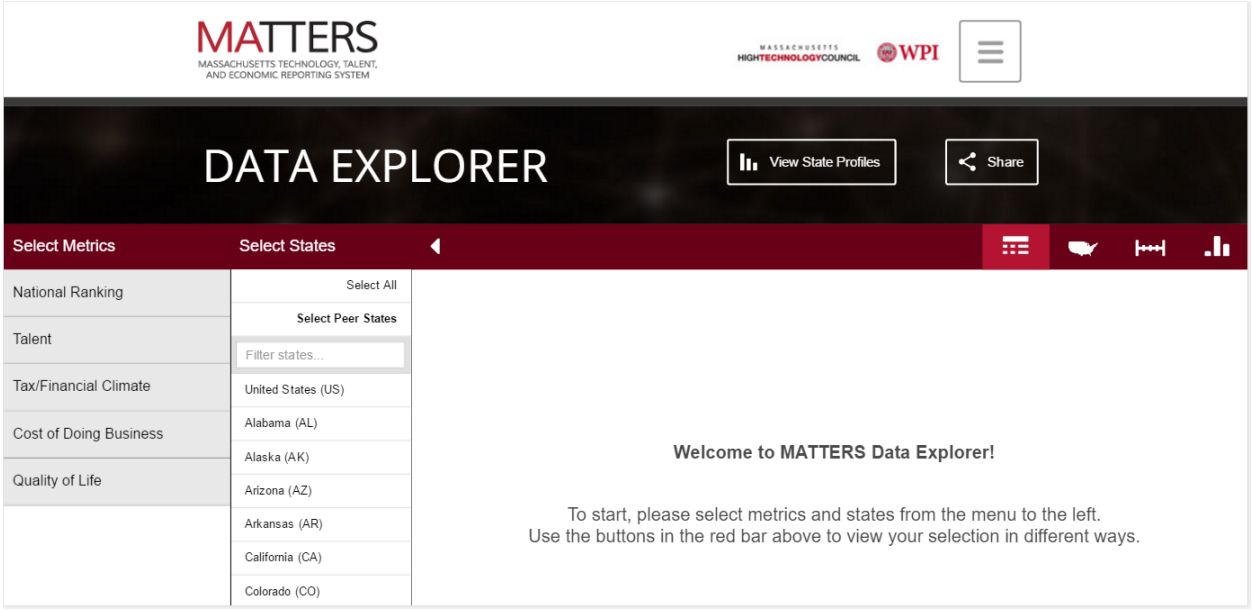

Figure 3.11. Data Explorer banner on larger desktop screens.

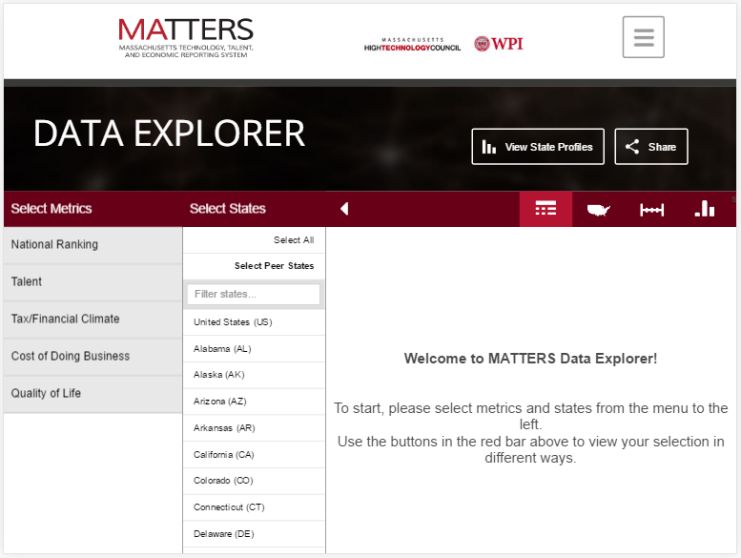

Figure 3.12. Data Explorer banner on medium tablet-sized screens.

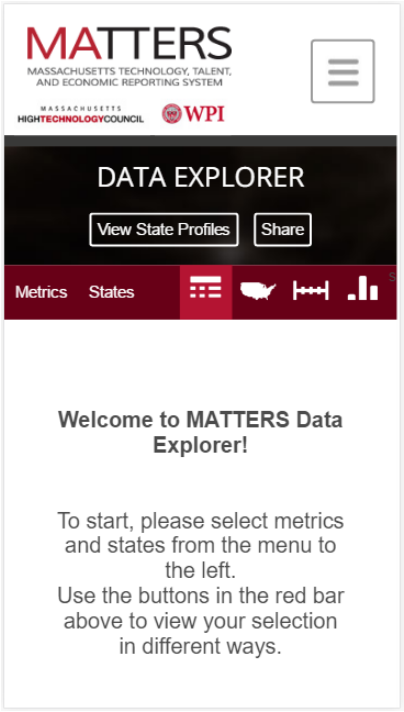

Figure 3.13. Data Explorer banner on small mobile device screens.

An example of this responsive design can be seen in Figures Figure 3.11 through Figure 3.13 in the adaptive nature of the Data Explorer banner in the Explorer page. More examples of responsive design in the site include, but are not limited to:

- The responsive maps on the homepage are hidden on small screens, replaced by a single image instead
- The placement and size of many of the buttons on the home, Explore, and State profile pages are updated dynamically as the screen size changes
- The metric and state menus on the left side of the Explorer page collapse on medium screens and become full-sized on small screens

CHAPTER 4: SURVEY AND EVALUATION

User Survey

Following the user studies done in the 2016 project and by Bentley University, I thought that it would be useful to MHTC to study how well these new and improved MATTERS 2.0 features performed in usability. We chose to use the Qualtrics research suite as it is made available to all members at WPI through wpi.qualtrics.com. (Qualtrics, 2017) The survey I wrote, which can be seen in Appendix A, was based on a slimmed-down version of the Bentley study Moderator's Guide. I removed some of the broader questions in the guide and added others that were more specific to features developed in MATTERS 2.0.

Before sending the survey out to start collecting data, I started by conducting face-to-face interviews with a handful of volunteers from WPI's Database System Research Group (DSRG), of which Professor Rundensteiner and Caitlin are members of. By conducting these interviews I was able to judge how long each part of the survey would take. I was also able to address parts of the survey that were not clear in their direction or the question they were asking. After modifying the survey based on the results of these interviews, I was ready to publish the survey to start collecting responses.

In order to get as many responses as possible, I first considered sending the survey to my fellow students at WPI and asking them to take it in order to help me with my research. However, such requests often lead to little to no participation unless there is an incentive included, usually in the form of being entered into some sort of raffle. Even then, turnout may still be low and students will tend to rush to finish surveys quickly in order to get to the end. Also, students at college are much more likely to be technologically intuitive than the average person, especially so students who are studying Computer Science.

I found an answer to both of these problems in a service provided by Amazon called Amazon Mechanical Turk. (Amazon, 2017) Amazon Turk is a service that allows businesses and developers to hire "workers" to perform certain tasks, such as categorization, data collection, and research surveys. Workers can view available tasks that have been posted by requesters, and requesters choose the amount of money the worker will be paid for each task. The fact that these workers are anonymous and more likely not previously familiar with the site is also helpful in providing us with a broader range of views approaching the sites.

Using Mechanical Turk, I was able to post my survey specifying a maximum of 500 responses, paying $0.10 per response and two days for the job to run. In order to keep the length of the survey short, I took the full survey that I had written and split it into two smaller surveys: one for the Data Explorer page which can be seen in Appendix B, and one for the State Profile page which can be seen in Appendix C. I used the above mentioned parameters for both posted jobs.

Because I had already written the survey in Qualtrics and because Qualtrics has a better data and analytics suite and a custom report maker I kept the surveys there. The two jobs posted to Mechanical Turk were simply links to either Qualtrics survey, and a code was added at the end of the survey to ensure that workers completed the entire survey before they were paid. Many of the images I used in the Survey Results section below were generated using Qualtrics software copyright © 2017 Qualtrics. Qualtrics and all other Qualtrics product or service names are registered trademarks or trademarks of Qualtrics, Provo, UT, USA. (Qualtrics, 2017)

Survey Results

Even though I specified a maximum of 500 responses, I did not expect to receive this amount and this was simply a limit to ensure that the cost to do the surveys was not too much.

There were a total of 129 responses recorded for the Data Explorer survey, and 130 for the State Profile survey. Of these, 110 workers completed the entire Data Explorer survey and 115 workers completed the State Profile survey and these numbers are the data that I did my analysis on.

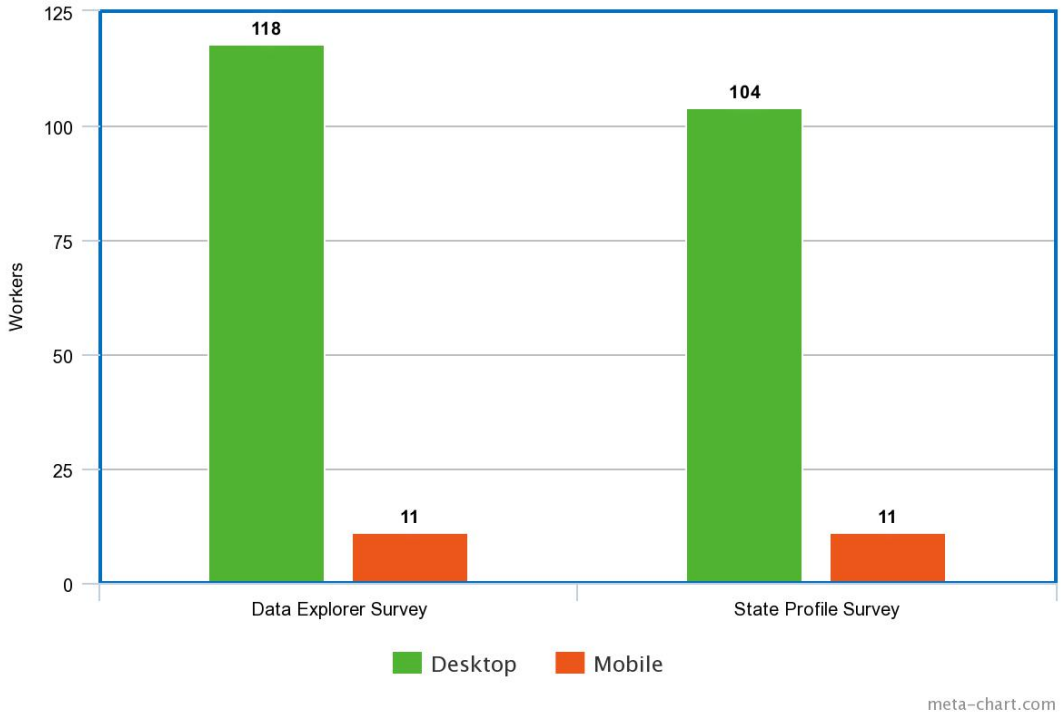

Figure 4.1. Desktop vs Mobile results collected.

Of the results collected, about 90% of the workers chose to use the desktop site and 10% chose to use the mobile site, as seen above in Figure 4.1. When testing responsive design styles, the majority of testing was done in Google Chrome using the built-in DevTools' Device Mode to simulate different mobile device screen sizes. For more about Chrome's DevTools and Device Mode, see "Simulate Mobile Devices with Device Mode" on Google Developers. (Bakaus, 2017) The results of this user study helps us test MATTERS by having people with access to devices we don't use the site, such as Apple devices using Safari, as well as devices of various screen

resolutions. The full breakdown of browsers used by workers can be seen in Figures Figure 4.2 and Figure 4.3, and the screen resolutions of all the workers that took the surveys and chose to use the desktop site can be seen in Figures Figure 4.4 and Figure 4.5. Of the workers that used the desktop site, a large majority were using a device that had a screen width between 1280 and 1440 pixels, which is larger than the threshold for most of the responsive design features.

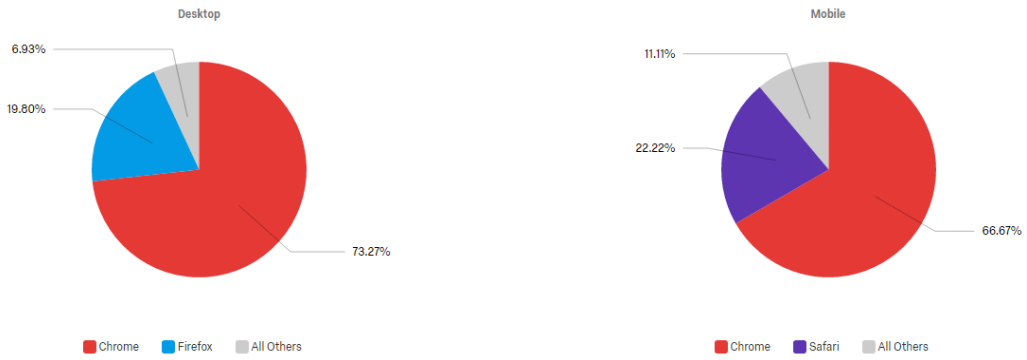

Figure 4.2. Browsers used in Data Explorer survey.

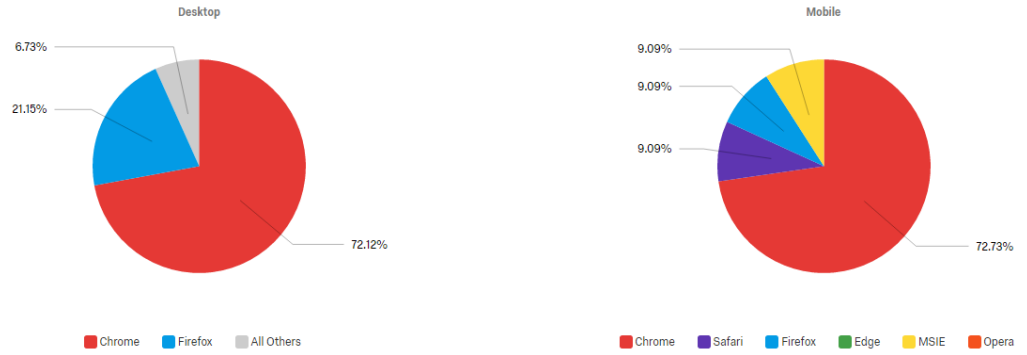

Figure 4.3. Browsers used in State Profile survey.

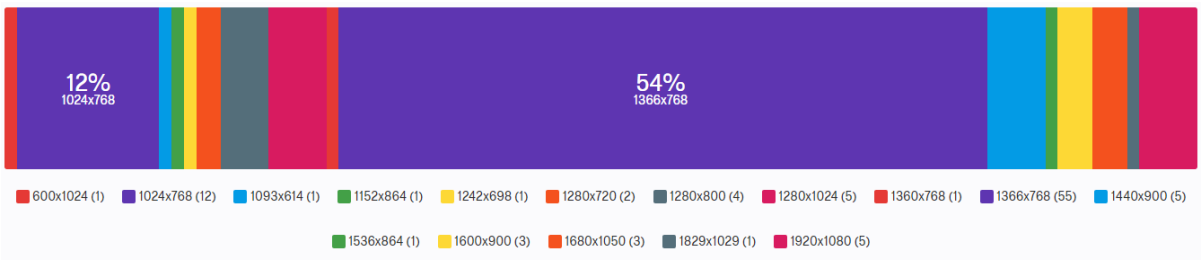

Figure 4.4. Screen resolutions from Data Explorer survey workers that used the Desktop site.

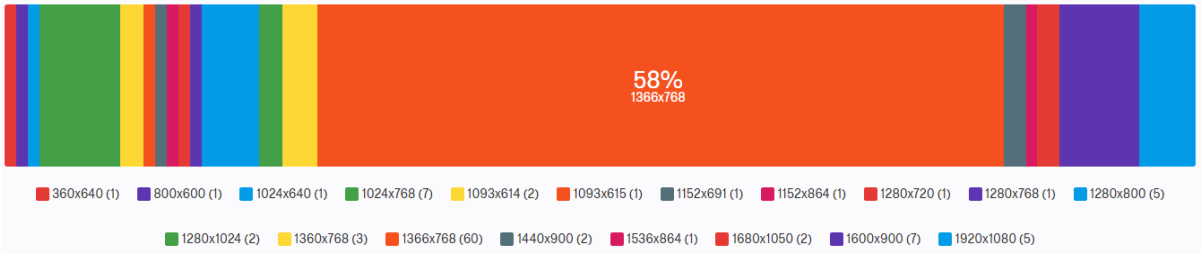

Figure 4.5. Screen resolutions from State Profile survey workers that used the Desktop site.

Question 10 from the Data Explorer survey reads: "How easily were you able to find the metrics you were looking for?" Reading the responses from the survey data, most of the workers were able to find the metrics they were looking for at least moderately well and none of the workers reported a problem in selecting or finding metrics. The responsive design of the site plays a large role in this, as the metric and state selection box becomes full screen on mobile devices so that the text is clear and easy to read. The responses from Question 10 can be seen in Figure 4.6 below.

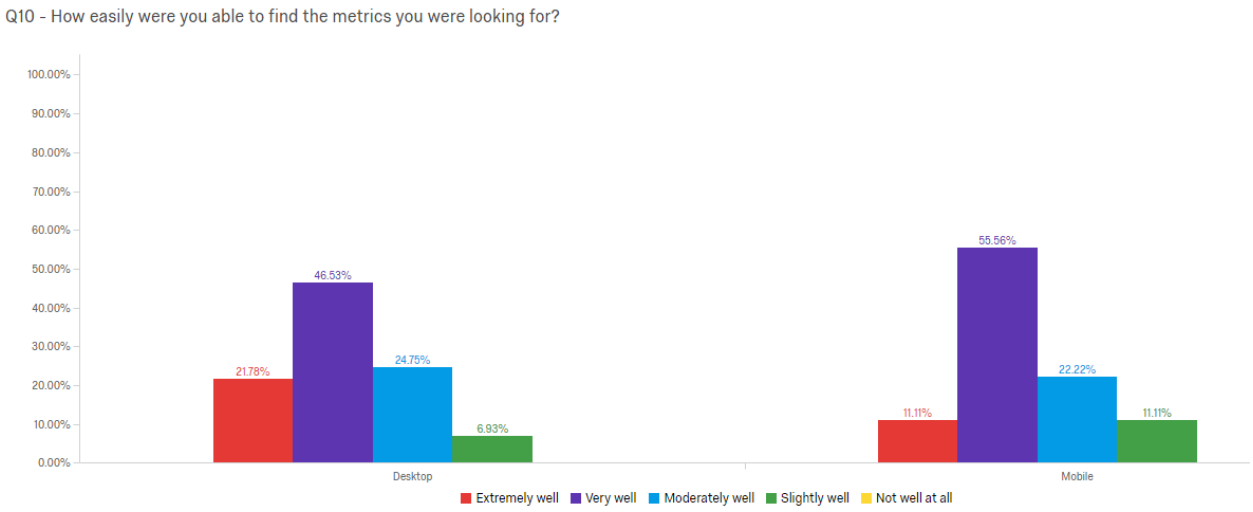

Figure 4.6. Question 10 from the Data Explorer survey broken down by desktop or mobile site.

Question 16 from the Data Explorer survey reads: "Could you clearly tell from the data which state had a better financial climate and availability of graduates?" The results from this

question were greatly positive and can be seen in Figure 4.7. Positive results from this question are indications that the visualizations on the Data Explorer page are efficient in their design purpose – that is, helping the user "visualize" the data and comparing the data of different states and years. Question 16 had users viewing strictly data that could be represented numerically. Question 18 is similar to question 16, except that the users are now viewing categorical data. The results from this question were still very positive, and can be seen in Figure 4.8. Many of the workers commented that they thought the site's handling of categorical data was quite efficient.

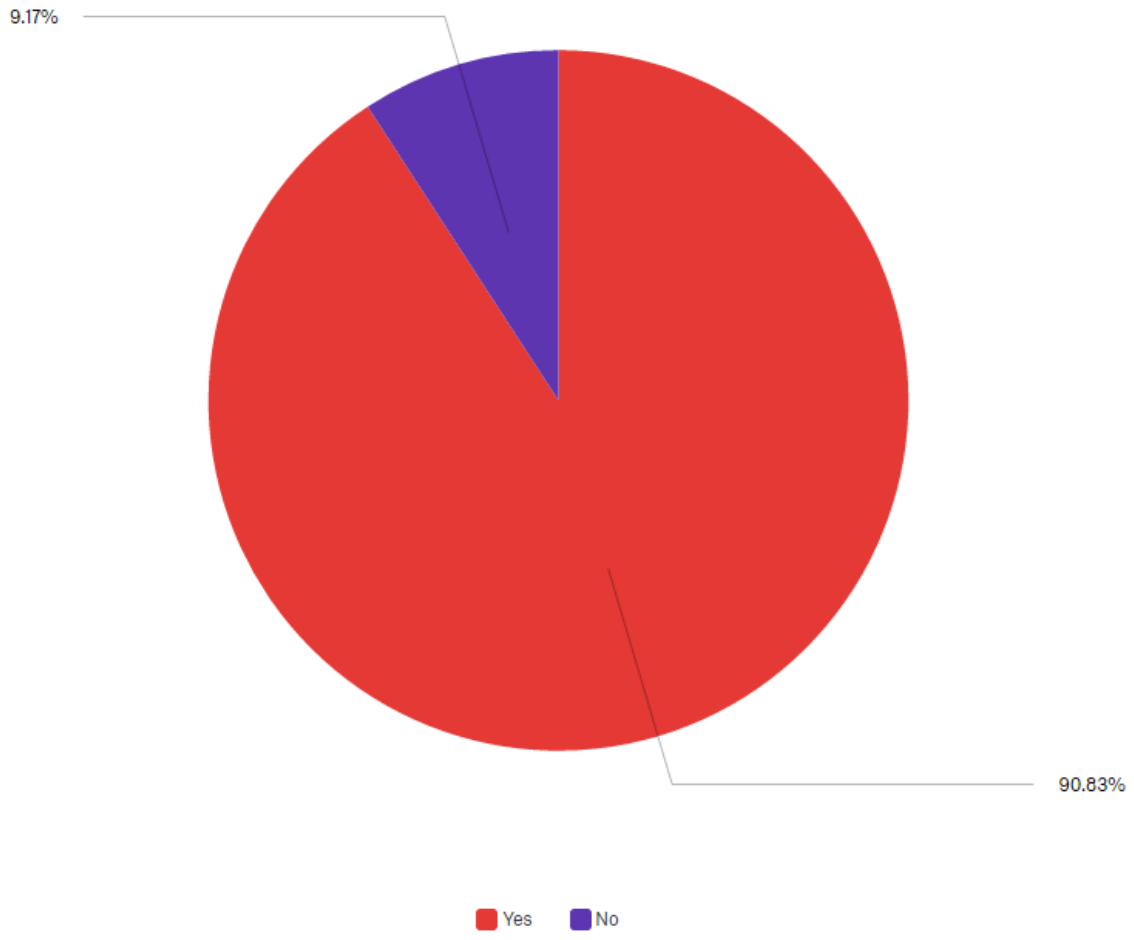

Figure 4.7. Question 16 from the Data Explorer survey.

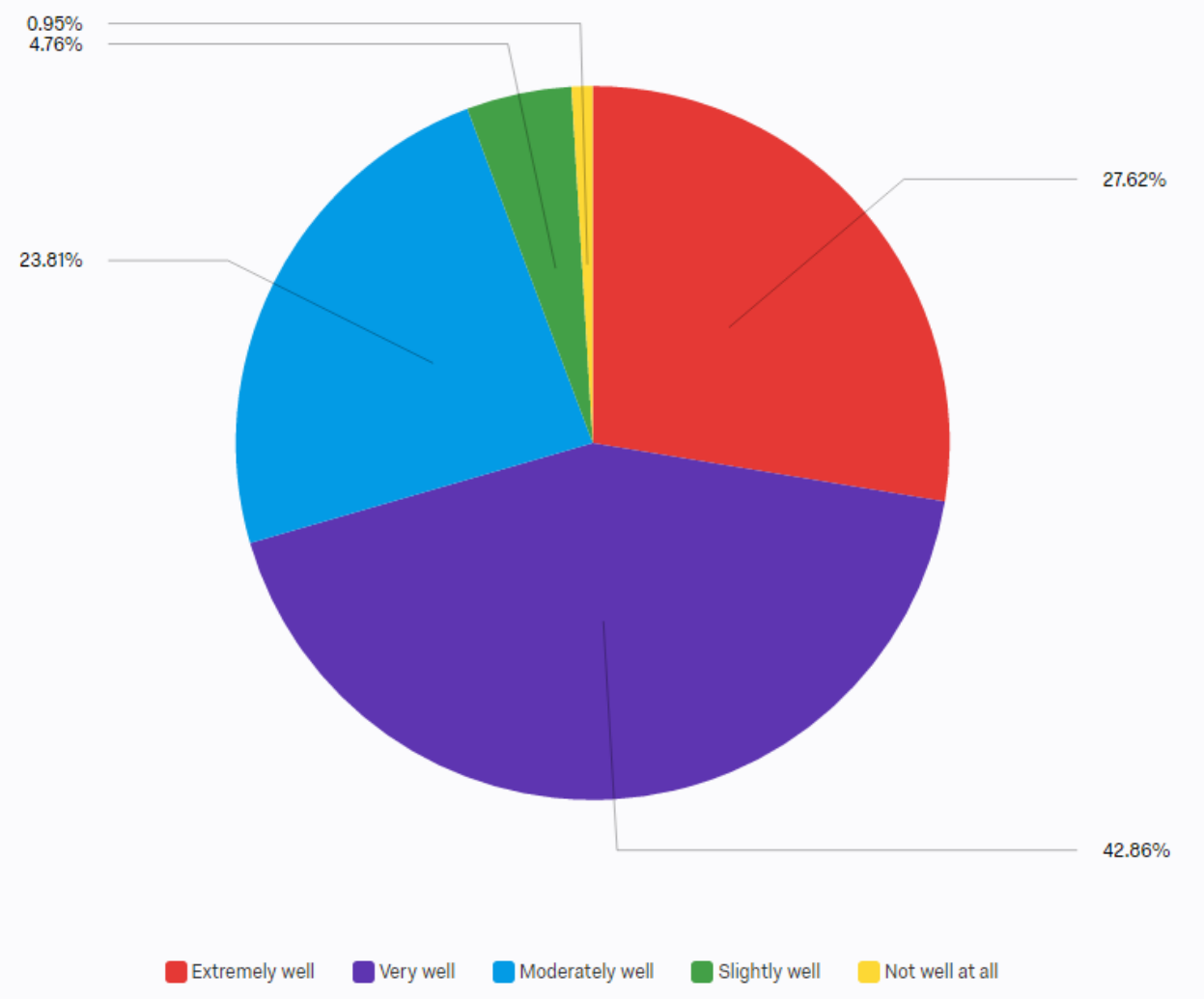

Figure 4.8. Question 18 from the Data Explorer survey.

Question 15 from the State Profile survey reads: “Were you able to find the factors that contribute to both Quality of Life rankings?” The breakdown of the responses to this question can be seen below in Figure 4.9 As you see, most of the workers were able to understand the data competently on the desktop site; however, the mobile site seemed to have less clarity. Normally, there are popovers that can be seen on the desktop site that explain what each index and metric measures and the source of that data. These popovers aren’t easily viewable on a

mobile device because you cannot hover your mouse over the title, and this may be contributing to the ambiguity reported in the data.

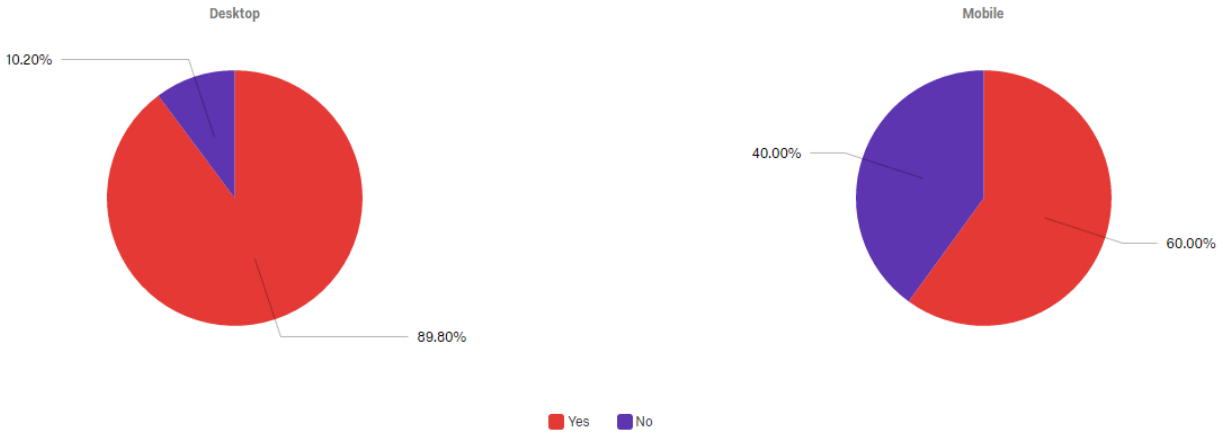

Figure 4.9. Question 15 from the State Profile survey broken down by desktop or mobile site.

After evaluating the feedback provided by the Amazon Turk workers, I was able to draw several useful pieces of feedback on areas of the site that could be improved or that users had problems with:

- The header of the Explore Page was a bit large and you must scroll down on smaller screens to use the explorer.
- The Explore Page visualizations have a minimum size, and because of this they are too big for the screen on mobile devices. There was also not a horizontal scrollbar visible for them to scroll it.
- It might be useful for new users on the site to be shown a brief tour of how to use the Data Explorer.
- The “Download” buttons on the Data Explorer visualizations are out of date and do not show up well in the downloaded documents.
- Printing the State Profile page does not work on many browsers and the content is overlapping
- Printing the State Profile page currently uses 6 pages to print and that may be undesirable for many users
- Some of the users were not able to tell what the strengths and weaknesses of each state were and most of them did not view the sources for the information provided on the site.

I found these points to be the most helpful in evaluating how well the MATTERS site performed. All of the survey data can be seen in Appendix D of this paper.

CHAPTER 5: CONCLUSIONS AND FUTURE UPDATES

After reading the feedback provided by Amazon Turk workers, as well as data collected in the face-to-face interview conducted with volunteers from the DSRG, I was able to compile a list of all the remaining bugs and improvements to be made to MATTERS before version 2.0 is released and published on MHTC's live site. That list includes the list from the above Survey Results section as well as a list that I made while performing my own testing:

- Footer on the Data Explorer page is not sitting at the bottom.
- It is hard or not possible to scroll the visualizations on the Data Explorer page when viewing from a mobile device. Zooming out works on some devices but then it is not possible to read the data.
- The hamburger menu in the top right of the page seems to be not aligned properly to its selection box on mobile devices, making it hard to select.
- Some of the data was not being populated properly from the database – may be that the database for the test site was not the most up to date version.
- Download buttons on each visualization in the Data Explorer need to be revisited and updated accordingly.
- Some of the rankings in the State Profile pages were showing up as 0.

Overall, many of the workers were happy with how the site looked and felt visually and how it presented the data it had to offer to the user. Aside from some technical problems encountered by users of the site on mobile devices, the feedback from the workers was positive. I believe that the results of the user study and of this project will be very useful to MHTC so that they can continue to enhance the user experiences and social impact of MATTERS in order to

further their goals of promoting and advocating technology in Massachusetts and in its government and many businesses.

After the completion of the surveys and interviews done for this project, and while writing this paper, I compiled these results and made Professor Rundensteiner and Caitlin aware of them so that they could be completed before the release of MATTERS 2.0 was published. I will continue working with them to address these issues after this project is complete. I have offered my development services to WPI and MHTC in their continued support and advancing of the MATTERS site.

USABILITY STUDY

MATTERS usability survey

Thank you for taking time to take this survey. You will be asked to visit the MATTERS website built by students at WPI for the Massachusetts High Technology Council (MHTC) and perform a few brief tasks and provide your feedback on the site. At the end of this survey you will be asked to enter your email address so to be entered in a raffle to win a gift card.

Browser Meta Info
- Browser (1)
- Version (2)
- Operating System (3)
- Screen Resolution (4)
- Flash Version (5)
- Java Support (6)
- User Agent (7)

When developing the MATTERS website, we tried to optimize it as much we can for mobile users. We will only ask you to take the survey once, so please pick desktop or mobile site now.
- ❍ Desktop (1)
- ❍ Mobile (2)

We'll ask some basic information about you first:

What Operating System are you using?
- ❍ Windows (1)
- ❍ Mac (2)
- ❍ Android (4)
- ❍ iOS (5)
- ❍ Other (3) _____
- ❍ Click to write Choice 6 (6)

What browser are you using?
- ❍ Chrome (1)
- ❍ Firefox (2)
- ❍ Safari (3)
- ❍ Internet Explorer (4)
- ❍ Other (5) _____

What is your current job / area of study?

What are your job responsibilities?

Are you familiar with the Massachusetts High Technology Council?
- ❍ Yes (1)
- ❍ No (2)

Are you familiar with the MATTERS website from the Massachusetts High Technology Council?
- ❍ Yes (1)
- ❍ No (2)

What do you know about the MATTERS website?

The next series of questions will be tasks based on using the MATTERS website. Each task will have a few questions following it based on your experience performing that task.

(if desktop site was selected) Task 1: Please open this link to the homepage now (in a new tab) and take a minute to familiarize yourself with the page: http://mhtc-vm1.cs.wpi.edu:8080/test/.

(if mobile site was selected) Task 1: Please open this link to the homepage now on your mobile device and take a minute to familiarize yourself with the page: http://mhtc-vm1.cs.wpi.edu:8080/test/.

Did you explore the site and click on different pages?
- ❍ Yes (1)
- ❍ No (2)

Did you find the maps on the homepage to be easy to read and understand what they mean?
- ❍ Extremely well (1)
- ❍ Very well (2)
- ❍ Moderately well (3)
- ❍ Slightly well (4)
- ❍ Not well at all (5)

Did you interact with the maps at all?
- ❍ Yes (1)
- ❍ No (2)

Did you have any issues navigating the home page?

Please share any input you have for the ranking maps or the homepage.

Task 2: Please navigate to the Data Explorer page and spend a few minutes to familiarize yourself with the data explorer and how to select and view data for certain metrics and states. Try both single metrics and groups of metrics. Then, view the data for the Number of Graduates and Corporate Income Tax Rate metrics for Massachusetts and California.

How easily were you able to find the metrics you were looking for?
- ❍ Extremely well (1)
- ❍ Very well (2)
- ❍ Moderately well (3)
- ❍ Slightly well (4)
- ❍ Not well at all (5)

Were the popups next to each metric clear on what data the metric measured?
- ❍ Yes (1)
- ❍ No (2)

Did you view the source for any of the metrics?
- ❍ Yes (1)
- ❍ No (2)

Did you look at data from different years?
- ❍ Yes (1)
- ❍ No (2)

Did you look at different data visualizations (charts)?
- ❍ Yes (1)
- ❍ No (2)

Note: you can look at different visualizations of the data by clicking the different chart buttons above the map

How well did the charts help you visualize and understand the data?
- ❍ Extremely well (1)
- ❍ Very well (2)
- ❍ Moderately well (3)
- ❍ Slightly well (4)
- ❍ Not well at all (5)

Could you clearly tell from the data which state had a better financial climate and availability of graduates?
- ❍ Yes (1)
- ❍ No (2)

If you wanted to share this information with a colleague, how would you?
- ☐ Email (1)
- ☐ Link (2)
- ☐ Social Media (3)
- ☐ Export (4)
- ☐ Other (5) _____

Please try using the Share button at the top of the page to share the data you have selected to a social media website. You can make the post private if you prefer. When clicking the link shared to social media, were you brought back to the same screen you were previously looking at?
- ❍ Yes (1)
- ❍ No (3)

Please give us any feedback you have for social media sharing.

Did you have any issues navigating the Explore page?

Please share any input you have for selecting metrics or the data visualizations (charts).

Please select the "Corporate Income Tax-Apportionment Method" metric from the Tax/Financial Climate menu and view the heatmap visualization. How well were you able to view this categorical data as opposed to the previous numeric data?
- ❍ Extremely well (4)
- ❍ Very well (5)
- ❍ Moderately well (6)
- ❍ Slightly well (7)
- ❍ Not well at all (8)

Please provide any feedback you have on viewing categorical data.

Task 3: Please navigate to the State Profiles page and view the Massachusetts profile. Take a minute to explore the page and learn what each MATTERS index looks at when ranking each state.

How did you navigate to this page?
- ❍ Menu at the top of the page (1)
- ❍ Through the homepage (2)
- ❍ Through the “View State Profiles” button (3)
- ❍ I could not find it (4)

Note: you can navigate to the State Profiles page by either clicking the State Profiles button on the home / explore pages or by the Profiles option in the menu at the top right of the page.

Were you able to tell what the strengths and weaknesses of this state were?
- ❍ Yes (1)
- ❍ No (2)

If you wanted to save this state profile to bring to a meeting, how would you do that?
- ❑ Print it out (1)
- ❑ Social Media (2)
- ❑ Screenshot (3)
- ❑ Link (4)
- ❑ Other (5) _____

Please try printing the page either through the Print button or your browser's print function. How well did the page look when printing?
- ❍ Extremely well (1)
- ❍ Very well (2)
- ❍ Moderately well (3)
- ❍ Slightly well (4)
- ❍ Not well at all (5)

Please give us any feedback you have for printing the page.

Task 3a: Suppose you see that Massachusetts is ranked #14 for quality of life and you want to see how that compares to California. Please go to the California state profile page and compare it's rankings to Massachusetts'.

Were you able to find both the Massachusetts and California state profiles?
- ❍ Yes (1)
- ❍ No (2)

Were you able to find the factors that contribute to both Quality of Life rankings?
- ❍ Yes (1)
- ❍ No (2)

How did you find the detailed rankings below the grey Index section?
- ❑ The "View Data Below" buttons (1)
- ❑ The arrows at the side of the page (2)
- ❑ Scrolling down the page manually (3)

Note: you can choose what state profile to view by selecting it in the drop-down menu at the top of the page.

Were you able to tell what the strengths and weaknesses of each state were?
- ❍ Yes (1)
- ❍ No (2)

Did you click on any of the sources on either profile page?
- ❍ Yes (1)
- ❍ No (2)

Did you have any issues navigating the State Profile page?

Please share any input you have for this page.

What are your overall impressions of this site?

What one or two things did you like best about using this site?

What one or two things did you like least about using this site?

Are there any features or metrics that you would expect or want be included in MATTERS that you did not see today?

Do you have any suggestions on how we can improve the site for mobile users?

Do you have any final comments or suggestions you would like to share with Massachusetts High Technology Council?

Thank you for taking the time to complete this survey! The results we collect in this survey will be analyzed and taken into consideration for future site updates and features. If you have any further feedback to give you may leave it here or email it to Justin Charron at jscharron@wpi.edu. This survey was part of an IQP on enhancing the user usability of the site. If you would like to work on future projects that involve this site or MHTC, you may contact Prof. Elke Rundensteiner in the CS department.

EXPLORE PAGE SURVEY

MATTERS Survey Data Explorer

Thank you for taking time to take this survey. You will be asked to visit the MATTERS website built by students at WPI for the Massachusetts High Technology Council (MHTC) and perform a brief task and provide your feedback on the page.

Browser Meta Info
- Browser (1)
- Version (2)
- Operating System (3)
- Screen Resolution (4)
- Flash Version (5)
- Java Support (6)
- User Agent (7)

When developing the MATTERS website, we tried to optimize it as much we can for mobile users. We will only ask you to take the survey once, so please pick desktop or mobile site now.
- ❍ Desktop (1)
- ❍ Mobile (2)

We'll ask some basic information about you first:

What Operating System are you using?
- ❍ Windows (1)
- ❍ Mac (2)
- ❍ Android (4)
- ❍ iOS (5)
- ❍ Other (3) _____
- ❍ Click to write Choice 6 (6)

What browser are you using?
- ❍ Chrome (1)
- ❍ Firefox (2)
- ❍ Safari (3)
- ❍ Internet Explorer (4)
- ❍ Other (5) _____

(if desktop site was selected) Task: Please open this link to the data explorer now (in a new tab): http://mhtc-vm1.cs.wpi.edu:8080/test/explore.

(if mobile site was selected) Task: Please open this link to the data explorer now on your mobile device: http://mhtc-vm1.cs.wpi.edu:8080/test/explore.

Please spend a few minutes to familiarize yourself with the data explorer and how to select and view data for certain metrics and states. Try both single metrics and groups of metrics. Then, view the data for the Number of Graduates and Corporate Income Tax Rate metrics for Massachusetts and California.

How easily were you able to find the metrics you were looking for?
- ❍ Extremely well (1)
- ❍ Very well (2)
- ❍ Moderately well (3)
- ❍ Slightly well (4)
- ❍ Not well at all (5)

Were the popups next to each metric clear on what data the metric measured?
- ❍ Yes (1)
- ❍ No (2)

Did you view the source for any of the metrics?
- ❍ Yes (1)
- ❍ No (2)

Did you look at different data visualizations (charts)?
- ❍ Yes (1)
- ❍ No (2)

Note: you can look at different visualizations of the data by clicking the different chart buttons above the map

How well did the charts help you visualize and understand the data?
- ❍ Extremely well (1)
- ❍ Very well (2)
- ❍ Moderately well (3)
- ❍ Slightly well (4)
- ❍ Not well at all (5)

Could you clearly tell from the data which state had a better financial climate and availability of graduates?
- ❍ Yes (1)
- ❍ No (2)

Did you have any issues navigating the Explore page?

Please select the "Corporate Income Tax-Apportionment Method" metric from the Tax/Financial Climate menu and view the heatmap visualization. How well were you able to view this categorical data as opposed to the previous numeric data?

- ❍ Extremely well (4)
- ❍ Very well (5)
- ❍ Moderately well (6)
- ❍ Slightly well (7)
- ❍ Not well at all (8)

Please provide any feedback you have on viewing categorical data.

Click yes to view survey code for Amazon Turk

- ❍ Yes (1)
- ❍ No (3)

Survey code is: MATTERS Usability Study

STATE PROFILE PAGE SURVEY

MATTERS Survey State Profile

Thank you for taking time to take this survey. You will be asked to visit the MATTERS website built by students at WPI for the Massachusetts High Technology Council (MHTC) and perform a brief task and provide your feedback on the page.

Browser Meta Info
- Browser (1)
- Version (2)
- Operating System (3)
- Screen Resolution (4)
- Flash Version (5)
- Java Support (6)
- User Agent (7)

When developing the MATTERS website, we tried to optimize it as much we can for mobile users. We will only ask you to take the survey once, so please pick desktop or mobile site now.
- ❍ Desktop (1)
- ❍ Mobile (2)

We'll ask some basic information about you first:

What Operating System are you using?
- ❍ Windows (1)
- ❍ Mac (2)
- ❍ Android (4)
- ❍ iOS (5)
- ❍ Other (3) _____
- ❍ Click to write Choice 6 (6)

What browser are you using?
- ❍ Chrome (1)
- ❍ Firefox (2)
- ❍ Safari (3)
- ❍ Internet Explorer (4)
- ❍ Other (5) _____

Task: Please open this link to the state profile page now (in a new tab) : http://mhtc-vm1.cs.wpi.edu:8080/test/profile.

Task: Please open this link to the state profile page now on your mobile device: http://mhtc-vm1.cs.wpi.edu:8080/test/profile.

Were you able to tell what the strengths and weaknesses of Massachusetts were?
- ❍ Yes (1)
- ❍ No (2)

If you wanted to save this state profile to bring to a meeting, how would you do that?
- ❑ Print it out (1)
- ❑ Social Media (2)
- ❑ Screenshot (3)
- ❑ Link (4)
- ❑ Other (5) _____

Please try printing the page either through the Print button or your browser's print function. How well did the page look when printing?
- ❍ Extremely well (1)
- ❍ Very well (2)
- ❍ Moderately well (3)
- ❍ Slightly well (4)
- ❍ Not well at all (5)

Please give us any feedback you have for printing the page.

Task 3a: Suppose you see that Massachusetts is ranked #14 for quality of life and you want to see how that compares to California. Please go to the California state profile page and compare it's rankings to Massachusetts'.

Were you able to find both the Massachusetts and California state profiles?
- ❍ Yes (1)
- ❍ No (2)

Were you able to find the factors that contribute to both Quality of Life rankings?
- ❍ Yes (1)
- ❍ No (2)

Were you able to tell what the strengths and weaknesses of each state were?
- ❍ Yes (1)
- ❍ No (2)

Did you click on any of the sources on either profile page?
- ❍ Yes (1)
- ❍ No (2)

Did you have any issues navigating the State Profile page?

Please share any input you have for this page.

Click yes to view survey code for Amazon Turk
- ❍ Yes (1)
- ❍ No (3)

Survey code is: MATTERS Usability Study

OTHER APPENDICES

The entire appendices of this project are contained in a zip file named “appendices.zip”.

The contents of this file are as follows:

- “MATTERS_usability_survey.docx” – Appendix A of this paper.
- “Survey_Data_Explorer.docx” – Appendix B of this paper.
- “Results_Data_Explorer.xlsx” – Results from Appendix B survey.
- “Survey_State_Profile.docx” – Appendix C of this paper.
- “Results_State_Profile.xlsx” – Results from Appendix C survey.
- “2016_report_Script_For_Investigators.pdf”, “2016_report_Survey.pdf”, and “2016_report_User_Results.xlsx” are all documents from the 2016 MQP’s user study.
- “bentley-report_aug2016.pdf” contains the results from the Bentley University user study done in 2016.
- “bentley-modguide-2016.pdf” is the moderator’s guide from the 2016 Bentley University user study.
- “MATTERS 2.0 Action Items.xlsx” is a list of action items that were worked on during the development of MATTERS 2.0.

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